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ABSTRACT

The State of Alaska has issued preventive maintenance guidelines for educational facilities designed to prevent premature failure, or to maximize or extend the useful life of a facility and its components, including roofing inspections, repainting, and door hardware adjustments. The handbook examines preventive maintenance state legislation, and the development and implementation of a preventive maintenance program that includes determining facility conditions and needs, assessing the resources needed, scheduling and assigning work, and developing reporting and feedback systems. Appendices provide a sample of a systems and components inventory list, and definitions of preventive maintenance terms adopted by the Bond Reimbursement and Grant Review Committee. (Contains 11 endnotes.) (GR)

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Alaska School Facilities Preventive Maintenance Handbook

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Preventive Maintenance Handbook

Overview

Preventive maintenance (PM) is the component of a facilities maintenance system which has as its goal the maximizing of the useful life of all building systems. Just as maintenance is an aspect of facility management which impacts virtually all other areas of the total facility equation, so PM, as a philosophy or mind-set, has a broad influence on the total maintenance effort. At its heart, preventive maintenance asks, "What can I do to make this item--be it an automobile, building, or piece of equipment--remain as good as new for as long as possible?"

Many discussions of maintenance relegate preventive maintenance to a small role, for example: "Preventive maintenance (PM) is defined in the maintenance management audit as periodically scheduled work on selected equipment, usually dynamic, to provide for required inspection, lubrication and adjustment."⁴

However, a broader application of the term is desirable to avoid fragmentation of the maintenance system into multiple subcomponents where routine, preventive, regular, recurring and other variations of maintenance each have their own definition (and accounting classification). For the purposes of meeting the requirement and intent of Alaska Statutes, the Department of Education sees preventive maintenance as:

*All activities which can be **regularly scheduled** to prevent premature failure or maximize or extend the useful life of a facility and its components. This will include items such as roof inspections, repainting, and door hardware adjustments as well as more traditional items such as bearing lubrication and belt replacements on HVAC equipment.*

It is essential that school boards, school district administration and staff make a commitment to this philosophy when considering their responsibilities in managing district facility assets. Preventive maintenance should be a key element of a school board's mission statement.

Legislation

State of Alaska legislation is very clear about preventive maintenance. By statute, a duty of each district's school board is to "provide for the development and implementation of a preventive maintenance program for school facilities." Some school districts share the duties of maintenance with another agency within the city or borough. This legislation in no way prohibits districts from acting in conjunction with these associated agencies to effect all or a part of their maintenance program, however, neither does doing so relieve the school board of its obligations in the area of preventive maintenance. The legislation goes on to say, "... in this paragraph, preventive maintenance means scheduled maintenance action that prevents the failure or extends the useful life of a facility, or facilities systems or components and that are cost effective on a life cycle basis." (AS14.14.090(10))

Legislation also does not allow capital funding for the accomplishment of preventive maintenance nor for projects caused by lack of it. A district requesting capital funding from either the school

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construction fund or major maintenance fund must provide "evidence that the project should be a capital improvement project and not part of a preventive maintenance program, or regular custodial care." An obvious conclusion to reviewing the pertinent legislation is that PM in Alaska is solely the responsibility of school districts and that funding must come from operating budgets which are in turn funded by community and state funds as well as federal funds allocated under the public school funding program.

Developing a Preventive Maintenance Program

Introduction

Alaska statutes give school districts two main responsibilities with regard to preventive maintenance. The first of these responsibilities is to *develop* a preventive maintenance program. This section will offer *guidance* in developing an effective program.

According to the Encyclopedia of Architecture, "Preventive maintenance programs should not be thought of as spontaneous natural events that will occur in the passage of time to meet the needs of the systems in place. Preventive maintenance programs begin with the acceptance of a need and the development of a considered, planned program for addressing the individual and different needs of each specific unit or system in a project."²

Many districts will have developed a traditional preventive maintenance program for various types of mechanical and some electrical equipment and components. Industry leaders in the design and manufacture of this type of equipment have long advocated and effectively promoted maintenance of their equipment. The early steps in this effort consisted of operations and maintenance manuals and, while these are still in use, have been supplemented by advanced, micro-processor based diagnostic and control systems.

In extending the scope of preventive maintenance to "maintenance work on any building system or component which can be scheduled", each district will be required to reassess their program's breadth and enhance it as necessary. The obvious first step in this process is identifying the facilities which need preventive maintenance (**by statute, all schools**) and the particular building systems and their components at those facilities which will respond effectively to preventive maintenance. This is followed by determining the present condition, establishing a level of maintenance and writing preventive maintenance tasks for each system or component.

Identification of Facilities, Systems and Components

From the list in Appendix A, select those systems and components which apply to each of the district's facilities. Districts may add additional items if desired and/or necessary. The list is intended to be a baseline for a comprehensive integrated maintenance program; it is not an exhaustive list of every component. Many buildings will have multiple system types within a particular category (e.g. roofing, package unit heaters, etc.) as well as multiple components of the same type (e.g. circulating pumps, water closets, toilet partitions, etc.). A specific preventive

Preventive Maintenance Handbook (cont.)

maintenance plan will need to be developed for each item. In addition, districts should consider the benefits in standardizing systems and components within a district.

This portion of preventive maintenance program development is designed to dovetail with other facility assessment devices such as the DOE School Facility Appraisal and School Condition Survey, as well as facilities audits as outlined by literature from the Association of Physical Plant Administrators (APPA).

Determining Present Conditions

Following the selection of the general categories of the items in each facility (based on that facility's construction and in-place systems) a detailed inventory is needed to quantify the systems and components and establish their current condition. In quantifying the items, information such as quantity, type, size, manufacturer, model, material specification, location, key parts, part numbers, and other item specific data will be gathered and documented. In establishing their current condition, a qualified technician or professional will need to make the assessment.

Establishing Levels of Maintenance

Preventive maintenance efforts range from visual inspections only, to performance testing and analysis, to minor adjustment, cleaning and/or lubrication, to replacement or reconditioning of components to complete overhauls.³

In establishing levels of maintenance, two tracks or approaches are required. One is to establish a basic life-span for the system (i.e. asphalt shingle roofing - 20yrs, oil-fired boiler, 22yrs, etc.). The second consideration is to answer the question, "What maintenance activities are needed to ensure that this particular system/component meets or exceeds its life expectancy?" Manufacturer's literature, experience, test results and industry averages are some ways to determine both acceptable life-cycles and what preventive maintenance work would result in achieving those life expectancies in the most efficient manner (i.e. the lowest total cost).

Preparing the Work Items Plan

According to Basil Castaldi, four elements make up any preventive maintenance work item. "In any prescribed maintenance program, the list of tasks to be performed is described in detail. The frequency and nature of the work are clearly stated. The materials to be used are specified in considerable depth and the manner in which the work is to be accomplished is expressed in simple language."⁴

School districts which are accredited by the Northwest Association of Schools and Colleges will recall that these accreditation standards include the following:

Standard III - School Plant and Equipment

"13. Inspection(s) of the school plant and equipment **shall** be made each school year by a qualified official and any deficiencies addressed."⁵

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This type of standard is effectively achieved by a thorough set of work items which incorporate the necessary levels of maintenance mentioned in the previous paragraph.

Implementing a Preventive Maintenance Program

Introduction

A second responsibility with which Alaska statutes charge school districts is to *implement* a preventive maintenance program. This section will offer *guidance* on carrying out the developed preventive maintenance work plan and will establish the importance of having management reports and a system of feedback from the field in implementing an effective program.

The basic task of PM implementation is matching needs with resources. Because both needs and resources are variables in the facilities management effort, implementation may occur once to initiate a PM program but will also require continuous monitoring and control.

Moving from the planning and development phase to implementation and operation almost always involves funding, regardless of the endeavor. Preventive maintenance is no exception. The portion of the Encyclopedia of Architecture devoted to implementation of a preventive maintenance program is largely a discussion of funding.⁶ For consideration, some findings from research concerning maintenance funding and resources are included in the following paragraphs.

Determining Necessary Resources

One effective strategy for determining the necessary resources is to start at the smallest detailed increment of the PM plan and combine them for the aggregate picture. Take each well developed PM work item and ask, "What skills (trained personnel), tools, materials (parts etc.), and time are needed to complete this work item?" Once these factors are tabulated and needs are clear, the supporting issues of space for shops and material staging along with transportation requirements can be addressed.

As previously mentioned, most of the resource requirements turn into a need for funds. In California, research showed that:

"If a planned maintenance program is followed, about 5 percent of a district's operating budget will be required to provide an adequate maintenance program. In addition to the 5 percent expenditure for the district's maintenance program, a reserve fund is needed for unanticipated and emergency maintenance expenditures. Another criterion for determining budget requirements is to calculate 2.9 percent of the current net building replacement cost or a projected cost based on the square footage of property to be maintained."⁷

Preventive Maintenance Handbook (cont.)

The Encyclopedia of Architecture indicates:

"The cost of preventive maintenance ranges according to the intent of the *plans developed*. To set a budget for this type of work, one may estimate 5% of the present value of the building for preventive maintenance activity. Perhaps 1.5% of the value of the building may be estimated for simpler structures or systems."⁸

While starting with the most detailed information and building up yields a comprehensive assessment of necessary resources, thinking broadly and systematically is required to arrive at the necessary organization with which to accomplish the PM program.

Scheduling and Assigning Work

The structure and organization of the preventive maintenance program must be in place before the effective scheduling of work can occur. Some operations and maintenance organizations establish a cross-disciplined PM work center whose main task is to inspect various systems and components (usually dynamic equipment) and write maintenance work orders. Following that, more traditional work centers such as plumbing, sheet metal, etc. are assigned the actual work tasks. Other maintenance organizations are oriented almost completely to preventive maintenance tasks with major crafts taking responsibility for components and systems within their respective areas. A small multi-disciplined workcenter handles routine maintenance and emergency repairs and, in some cases, minor improvement work. These are just two of many options available in establishing a structure for preventive maintenance scheduling.

The heart of any preventive maintenance program is assigning and executing specific PM tasks. This is almost always done on a work order system. This element of the PM program takes the work items developed for each component and assigns them to the appropriate maintenance craftsperson or team according to the established structure and schedule. Another factor to consider when scheduling PM work is productivity. Scheduling and work assignments are among the most significant influences in worker productivity.

Simple preventive maintenance programs can be executed using a manual system of scheduling and work tracking. One approach to such a method is described by one writer as follows:

"He or she may wish to record each task to be performed on a card. This may include a description of the task and the tools and the materials to be used. These cards may well serve as a tickler file or a reminder to the *maintenance manager* as to when the task should be completed. He or she should note on the card the date of the next time when the work is required and file all of the cards chronologically by date, starting with the current date. In this way, the *maintenance manager* will know at a glance what needs to be completed within a given month, week or day. Once the work is completed, he or she can record what was done on the back of the card."⁹

Preventive Maintenance Handbook (cont.)

Although preventive maintenance tasks can be managed using a manual system, the automated maintenance management system is now state-of-the-art and financially affordable for even the smallest maintenance organizations. In many school districts, maintenance managers are running comprehensive computerized maintenance management programs particularly suited to preventive maintenance. Once pertinent data is entered into the database system, work orders detailing the preventive maintenance requirements can be generated and tracked. More advanced programs have an integral query phase which prompts maintenance managers for necessary input and provides industry standards for certain maintenance tasks. "It is estimated that there are more than fifty (50) suppliers of maintenance software packages with price variations based on need and capacity."¹⁰

In addition to automating the list of items needing preventive maintenance at specified times, most maintenance management software programs also provide the capability for a computerized building data file. This database of facility requirements can be used to generate a wide variety of accurate reports on matters related to building maintenance and operations and their associated costs. To a certain extent the integrated maintenance system, which incorporates both daily maintenance tasks and long range planning along with continuous monitoring and evaluation, depends upon an automated database of facility information. Effective preventive maintenance programs depend on feedback from maintenance personnel and a reporting/tracking system of associated costs to maintain the proper balance between preventive maintenance and renewal and replacement efforts.

Reporting Systems and Feedback

District maintenance programs should undergo periodic audits of their effectiveness. This can occur both at the workers task level and at the maintenance management level. Evaluations can be done either internally or through the use of an outside evaluation team. Maintenance management audits generally consider the following four factors:

- Productivity - the portion of a worker's time that is directly productive.
- Performance - how well the individual is working, i.e., is work being completed as planned?
- Work Quality - are they producing a satisfactory work product.
- Priority - effective allocation of available time to the most important tasks.¹¹

Though maintenance management audits may look at symptoms of ineffective maintenance at the worker/task level (i.e. number of call-backs, work completed on schedule, etc.), a management audit's focus, as the name implies, is on improvements through better management.

In addition to informal and formal audits, a reporting system should be established to analyze a district's maintenance system to achieve the lowest total maintenance costs. The optimum maintenance program is one in which the total costs for PM and repair and replacement is the lowest.

Notes

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Appendix A

Sample Systems and Components Inventory List

Foundation and Substructure

- Footings
- Foundation walls
- Slab/beams on grade
- Piling/Posts
 - thermopiles
- Reinforcing
- Connectors
- Waterproofing
- Insulation
- Underdrains

Superstructure

- Columns
- Beams
- Rigid frames
- Floor structure
 - joists
 - deck/slab/sheathing
 - ramps
- Roof structure
 - trusses
 - deck/slab/sheathing
- Monolithic bearing walls
- Stairs and railings
- Structural bracing
- Welds/connectors

Exterior Wall Systems

- Wall construction
- Cladding/sheathing
- Doors
 - frame
 - door unit
 - hardware
- Glazing systems
 - frame
 - glazing
 - hardware
- curtain walls
- storefronts
- Balcony walls/railings
- Louvers and screens
- Expansion/seismic joints
- Insulation
- Protective coating
- Sealants

Appendix A

Sample Systems and Components Inventory (cont.)

Roof Systems

- Roofing
- Insulation
- Paving and ballast
- Curbs/supports
- Expansion/seismic joints
- Drains, gutters and d.s.
- Drywells
- Flashing and trim
- Fasteners
- Snow stops
- Roof openings

Interior Construction

- Fixed partitions
- Demountable partitions
- Retractable partitions
- Doors
 - frame
 - door unit
 - hardware
- Glazing systems
 - frame
 - glazing
 - storefronts/entrances
- Interior finishes
 - carpet
 - resilient tile/sheet
 - ceramic/clay tile
 - terrazzo
 - paint
 - vinyl/fabric wall cover
 - wood
 - metal panels
- Ceiling system
 - suspension grid
 - acoustical units
 - soffits (metal/gyp.)

Specialties

- Toilet partitions
- Display boards
- Projection screens
- Display cases
- Lockers
- Flag poles

Appendix A

Sample Systems and Components Inventory (cont.)

Conveying Systems

- Elevators
- Moving stairs/walks
- Dumbwaiters
- Pneumatic tube
- Lifts (material/personnel)

Heating Systems

- Boilers
- Furnaces
- Burners
- Fuel tanks & distribution
- Heat transfer equipment
 - heat exchangers
 - coils
- Terminal/package units
- Fin tubes/radiators
- Heating accessories
 - dampers/draft control
 - breeching and ductwork
 - stacks
 - insulation
 - piping
 - valves

Air Handling Systems

- Air handling units
- Unit ventilators
- Fans
- Inlets/outlets
- Ducting systems
 - dampers
 - filters
 - mixing boxes
 - sound attenuators
- Humidifiers
- Dust collection systems

Cooling Systems

- Condensing units
- Compressors
- Heat exchangers
- Packaged A/C units
- Chillers
- Absorption units

Mechanical Controls

- Compressors
- Pneumatic valves/levers

Appendix A

Sample Systems and Components Inventory (cont.)

- Pneumatic tubing
- Electronic controls

Plumbing Systems

- Cold water piping
- Water heater
- Hot water piping
- Pumps
 - sewage lift
 - water booster
 - circulating
 - sump
- Valves and traps
- Insulation
- Plumbing fixtures
 - sinks and faucets
 - toilets/urinals
 - coolers/drinking fountains
 - exterior hose bibs
- Waste vents
- Waste piping
- Septic tanks

Fire Protection/Suppression Systems

- Sprinkler piping
- Backflow preventers
- Sprinkler heads
- Fire extinguishers
- Fire hose system
- Standpipe connection
- Fire pumps
- Grease hood extinguisher

Power Generation and Transmission

- Generators
- Engines/turbines
- Transfer switches
- Transformers
- Service wiring
- Substation
- Switchgear
- Bus ducting
- Overcurrent protection

Power Distribution Systems

- Main distribution panel
- Wiring
- Conduits
- Raceway

Appendix A

Sample Systems and Components Inventory (cont.)

- Cable trays
- Distribution panels
- Electrical receptacles
- Circuit breakers
- Baseboard heaters
- Motors/fans
- Heat trace

Lighting Systems:

- Fixtures
 - fluorescent fixtures
 - incandescent fixtures
 - HID fixtures
- Wiring
- Lighting panels
- Emergency lighting
- Standby lighting
- Exterior lighting

Signal Systems

- Computer data
- Public address
- Television
- Telephone
- Clock system
- Satellite delivery system
- Fire alarms
- Fire door hold-opens
- Security alarm/devices

Landscaping Systems

- Irrigation
- Tree/shrub plantings
- Flower bed plantings
- Turf/lawn
- Walks/plazas

Playfields and Playground Systems

- Football fields
- Baseball/softball fields
- Hard surface courts
- Hockey/skating rinks
- Playdecks
- Swings
- Climbing toys
- Safety mats
- Gravel and containment
- Markings/painting

Appendix A

Sample Systems and Components Inventory (cont.)

Vehicular Systems

- Parking lots
- Roads/drives
- Curbs
- Fire lanes

Site Utilities

- Fuel tanks
- Fuel distribution piping
- Storm drainage
- Fire hydrant systems
- Electrical power
- Pole-mounted lighting

Equipment

- Furnishings
 - classroom furniture
 - seating
 - rugs and mats
- Fixtures
 - window treatments
 - artwork
 - vending
- Equipment
 - waste handling
 - loading dock
 - parking equipment
 - postal
 - food service
 - woodworking shop
 - auto/engine shop
- Special construction
 - vaults
 - swimming pools
 - acoustical enclosures
 - raised computer flooring

Appendix B

Definitions

Component

A part of a system in the school facility.

Component Repair or Replacement

The unscheduled repair or replacement of faulty components, materials, or products caused by factors beyond the control of maintenance personnel.

Custodial Care

The day to day and periodic cleaning, painting, and replacement of disposable supplies to maintain the facility in safe, clean and orderly condition.

Deferred Maintenance

Custodial care, routine maintenance, or preventive maintenance that is postponed for lack of funds, resources, or other reasons.

Major Maintenance

Facility renewal that requires major repair or rehabilitation to protect the structure and correct building code deficiencies, and shall exceed \$25,000 per project, per site. It must be demonstrated, using evidence acceptable to the department that (1) the district has adhered to its regular preventive, routine and/or custodial maintenance schedule for the identified project request, and (2) preventive maintenance is no longer cost effective.

Preventive Maintenance

The regularly scheduled activities that carry out the diagnostic and corrective actions necessary to prevent premature failure or maximize or extend the useful life of a facility and/or its components. It involves a planned and implemented program of inspection, servicing, testing and replacement of systems and components that is cost effective on a life-cycle basis.

Renewal or Replacement

A scheduled and anticipated systematic upgrading of a facility system or component to rehabilitate it to a renewed functioning standard.

System(s)

An assembly of components created to perform specific functions in a school facility, such as a roof system, mechanical system or electrical system.

Note: The above definitions are those adopted by the Bond Reimbursement and Grant Review Committee 4-18-97.